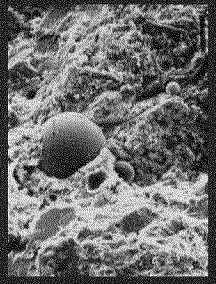
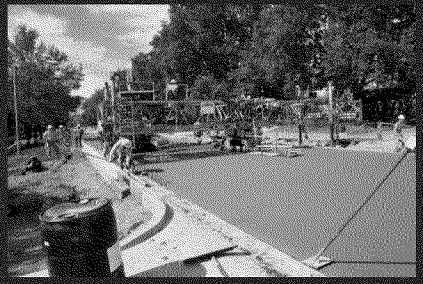
Coal Ash 101:
Overview of Beneficial Use of Coal Combustion Products





U.S. EPA Built Environment Group

May 24, 2017

ACAA

American Coal Ash Association

- Founded in 1968
- Headquartered in Farmington Hills, MI
- 140 members – utilities, marketers, contractors, equipment suppliers, consultants, academics
- Active with similar organizations around the world

ACAA Mission

The mission of the American Coal Ash Association is to encourage beneficial use of CCP in ways that are

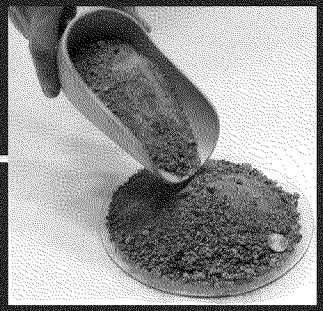
- *environmentally responsible,*
- *technically sound,*
- *commercially competitive,*
- *supportive of a sustainable global community.*

What is Coal Ash?

- Coal ash is the generic term referring to several distinct materials produced when coal is combusted to generate electricity.
  - Fly Ash
  - Bottom Ash
  - Flue Gas Desulfurization (FGD) Materials
- Also known as “Coal Combustion Products” and “Coal Combustion Residuals”
- Coal ash safely offers extraordinary environmental and economic benefits when properly managed.

Coal Combustion Products

- Fly ash – cement manufacture, concrete products, geotechnical
- Bottom ash – aggregate, geotechnical
- Boiler slag – roofing granules, blasting grit
- Flue gas desulfurization gypsum – wallboard, agriculture, cement manufacturing

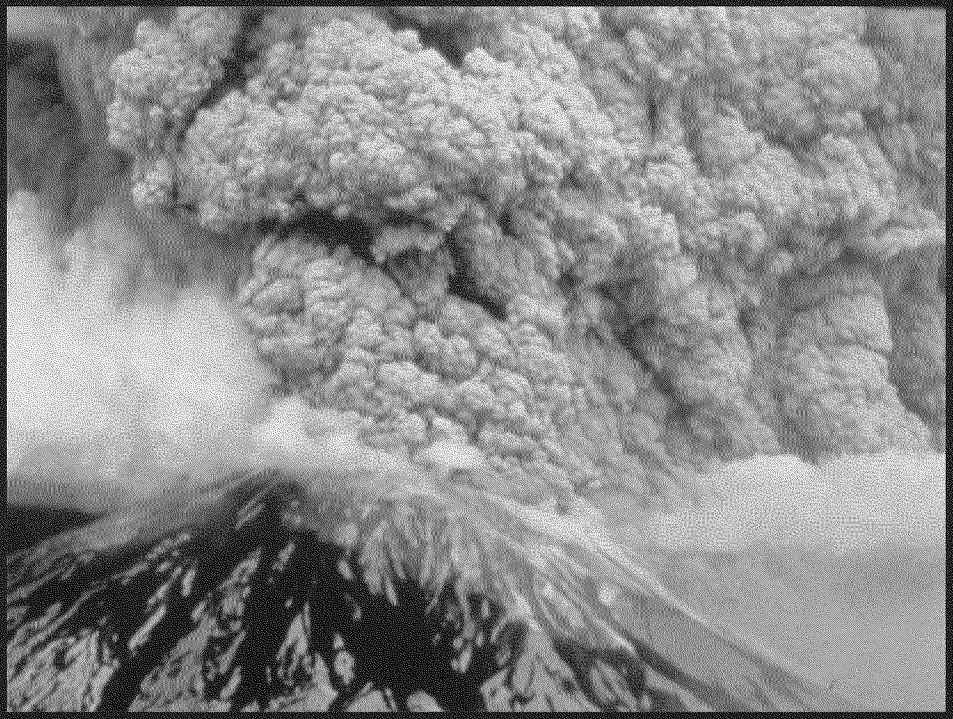


Types of Beneficial Uses

- Concrete and concrete products
- Cement production
- Structural and flowable fills
- Road base
- Mineral fillers
- Gypsum wallboard
- Soil and waste stabilization
- Traction control
- Blasting grit and roofing granules
- Aggregate
- Agricultural
- Mining

The Story of Coal Fly Ash

Technology as old as the Romans

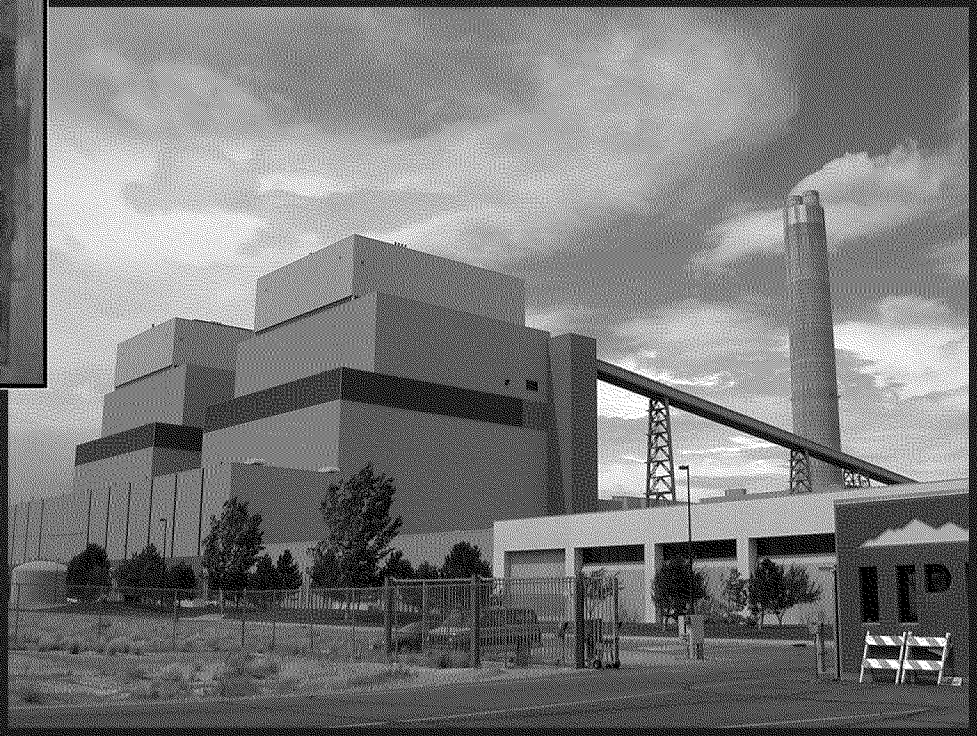


Coal Fly Ash is a "Pozzolan"

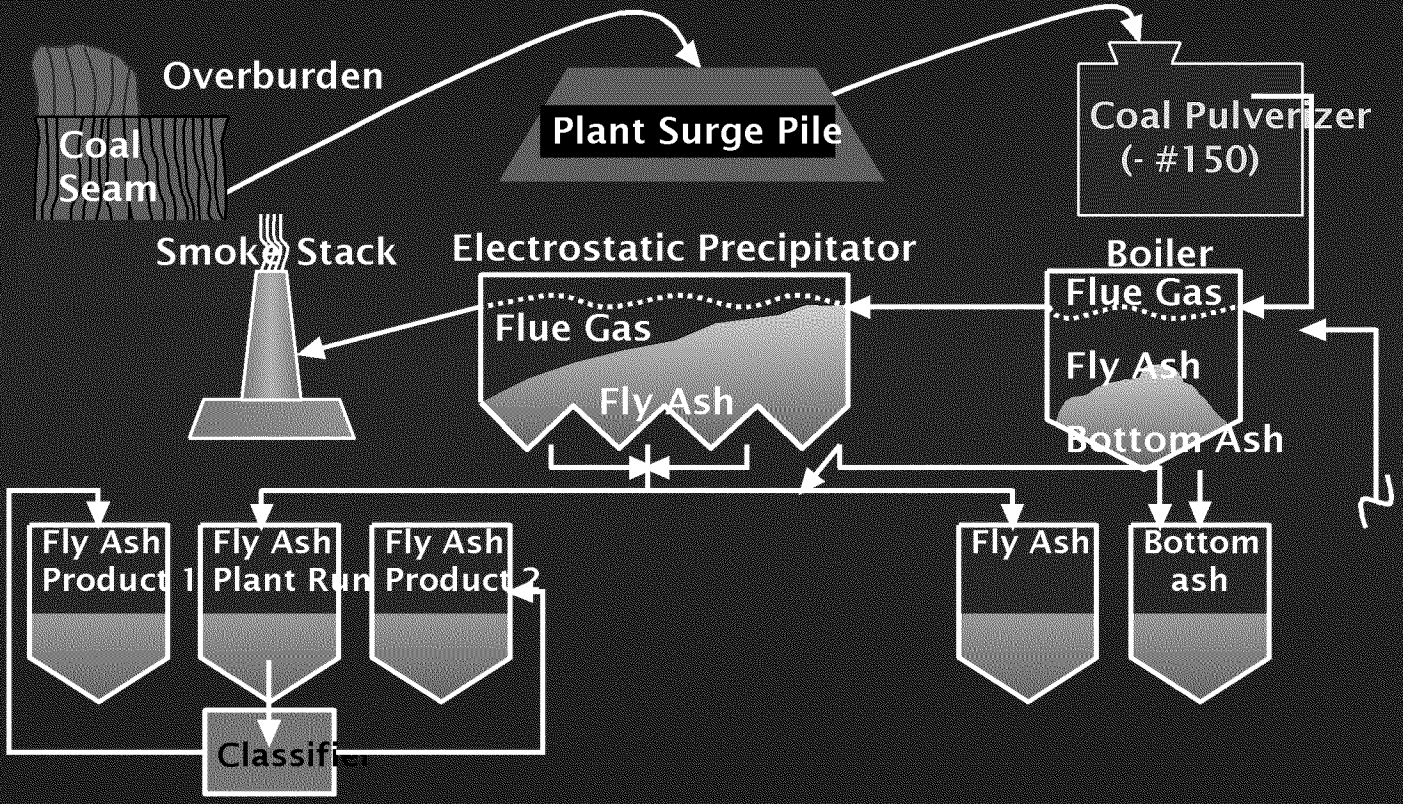
- "A siliceous or siliceous and aluminous material which in itself possesses little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties."

A Well-Known Pozzolan Project

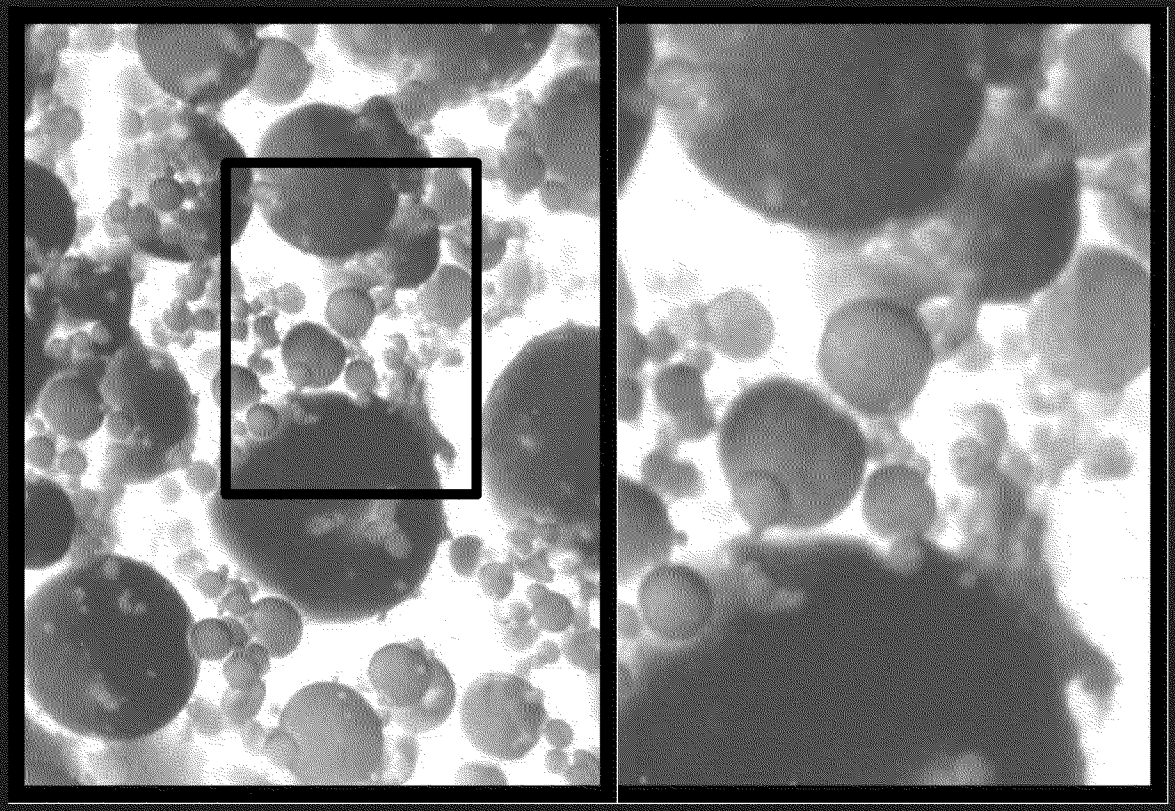
Source of Modern Pozzolans



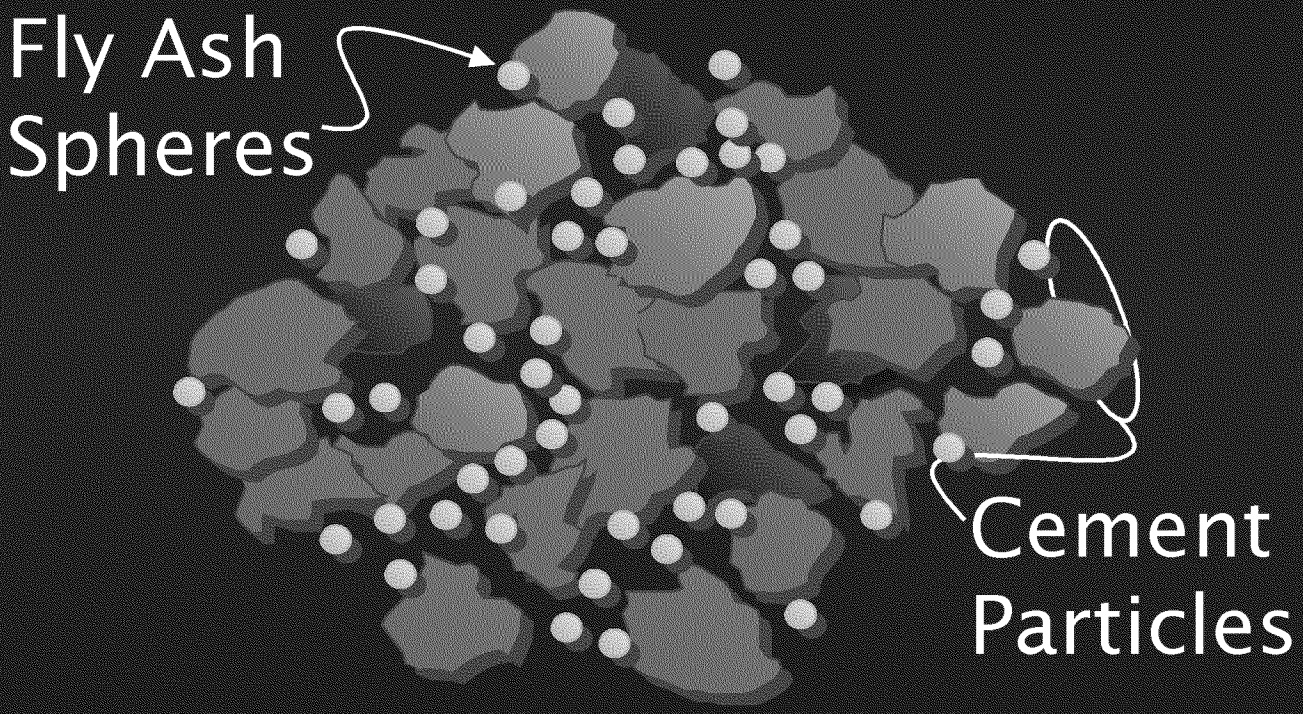
How Coal Ash is Produced



Fly Ash Under the Microscope

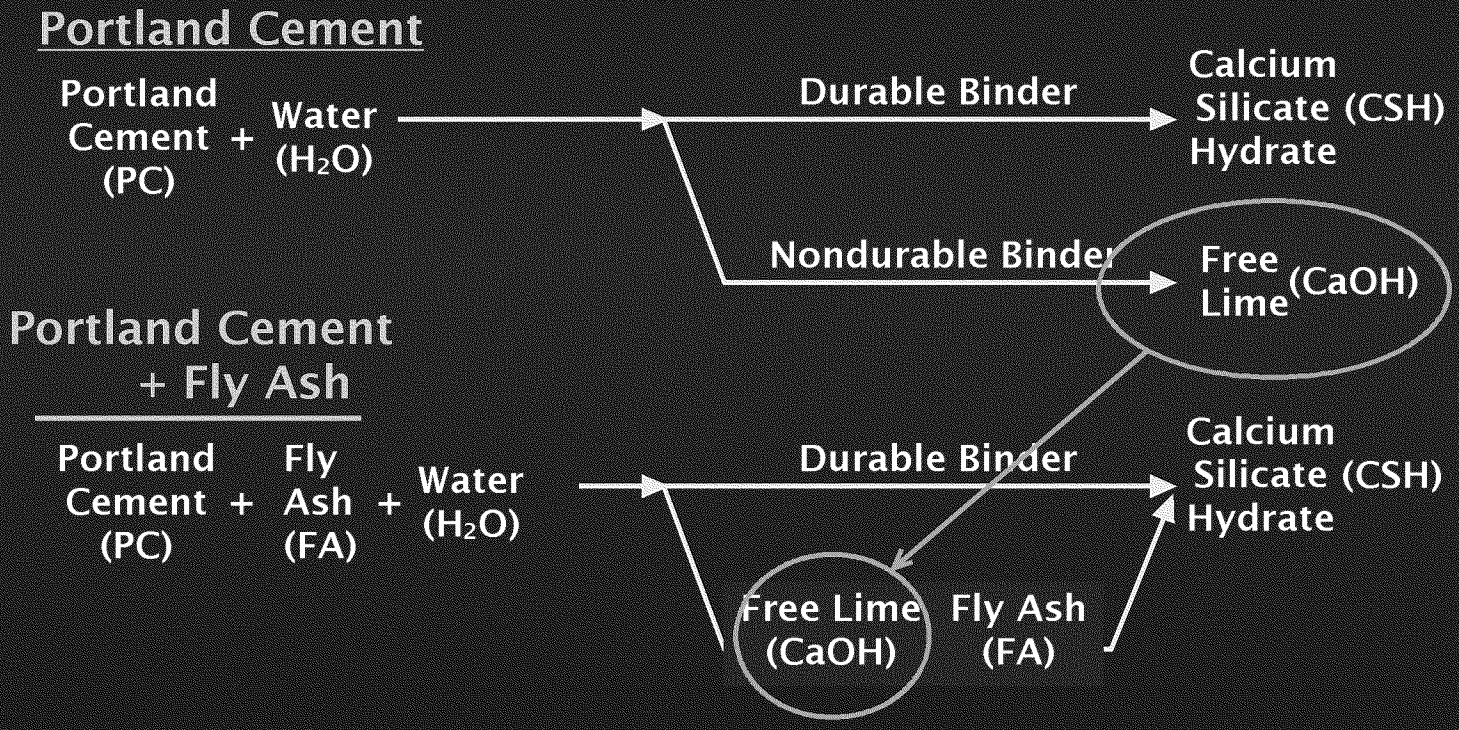


Mechanical Properties of Ash



Chemical Properties of Ash

Through Pozzolanic Activity, Fly Ash Combines with Free Lime to Produce the Same Cementitious Compounds Formed by the Hydration of Portland Cement



ASTM Specification for Ash

		F	C	N
Chemical				
$SiO_2 + Al_2O_3 + Fe_2O_3$	min %	70	50	70
SO_3	max %	5	5	4
Moisture Content	max %	3	3	3
Loss on Ignition	max %	6	6	10
Optional Chemical				
Available Alkalies	max %	1.5	1.5	1.5
Physical				
Fineness + 325 Mesh	max %	34	34	34
Strength Activity/Cem.	min %	75	75	75
Water Requirement	max %	105	105	115
Autoclave Expansion	max %	0.8	0.8	0.8

		F	C	N
Physical (continued)				
Uniformity Requirements				
Density Max. Var.	max %	5	5	5
Fineness Points Var.	max %	5	5	5
Optional Physical				
Multiple factor		225	-	-
Inc. In Drying Shrinkage	max %	0.03	0.03	0.03
Uniformity Requirements				
A.E. Admixture Demand	max %	20	20	20
Control of ASR				
Expansion, % of low alkali cement	max %	100	100	100
Sulfate Resistance				
Moderate exposure, 6 months	max%	0.10	0.10	0.10
High exposure, 6 months	max%	0.05	0.05	0.05

Coal Ash for Concrete

- Improving concrete performance
  - Mechanical and chemical properties of coal fly ash contribute to improved concrete durability
  - Also widely used to mitigate reactive aggregates, sulfate soils, and other common engineering problems
- Improving sustainability
  - Using coal fly ash reduces landfill utilization and conserves natural resources
  - Fly ash used in place of cement accounts for millions of tons of annual greenhouse gas emissions reductions
- Reducing costs
  - In many regions, fly ash is significantly less expensive than cement and alternative supplementary cementitious materials
  - ARTBA study estimates $100 billion benefit to road and bridge construction over 20 years

Each Ton of Ash Equals…

Energy Savings and Life Cycle Impacts of One Ton of Fly Ash in Concrete[1]

Metric Measurement	Amount
Energy Savings in dollars	$129.10
Water savings	376.3 liters or 99.4 gallons
Avoided total CO_2 equivalent green house gases (ave.)	718,000 grams or apx. 0.80 tons per ton of portland cement
Passenger cars not driven for a year	0.2
Avoided gasoline consumption	310 liters or 82 gallons
Avoided oil consumption	1.7 barrels or 53.5 gallons

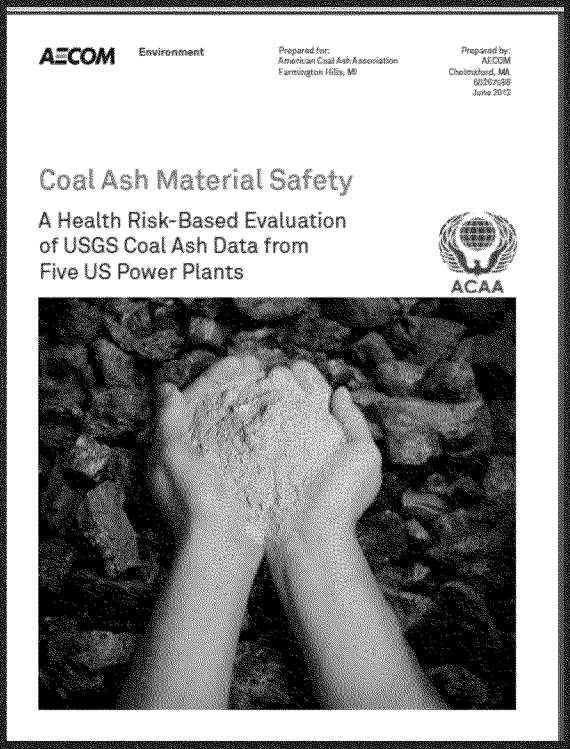
1. June 3, 2008 EPA Report to Congress (EPA530-R-08-007) Study on Increasing the Usage of Recovered Mineral Components in Federally Funded Projects Involving Procurement of Cement or Concrete to Address the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for User.

38 Years of Regulatory Effort

- 1976 – Resource Conservation and Recovery Act
- 1980 – Bevill Amendment passed
- 1993 – First Determination by EPA that CCP does not warrant regulation as hazardous waste
- 2000 – **Final** Determination by EPA that CCP does not warrant regulation as hazardous waste
- 2009 – EPA reopens coal ash rulemaking
- 2014 – EPA Final Rule regulating coal ash disposal as non-hazardous

Subtitle D Consistent with Science

- With few exceptions constituent concentrations in **coal ash are below screening levels for residential soils**, and are similar in concentration to background US soils.
- Thus, not only does coal ash not qualify as a hazardous substance from a regulatory perspective, **it would not be classified as hazardous on a human health risk basis.**
- Because exposure to coal ash used in **beneficial applications**, such as concrete, road base, or structural fill would be much lower than a residential scenario, these uses would also not pose a direct contact risk to human health.



History of CCP Utilization

- 1990s – Beneficial use volumes grow from approximately 20 million to 30 million tons
- 2000 – Beneficial use volume **32.1** million tons as EPA issues Final Regulatory Determination
- 2008 – Beneficial use volume **60.6** million tons
- 2009-13 – Beneficial use stalls in face of regulatory uncertainty and misleading publicity regarding safety of coal ash
- 2014 – Recovery begins, led by increases in fly ash utilization for concrete and synthetic gypsum utilization for wallboard and agriculture
- 2015 – Beneficial use rate tops 50% for first time

Role of C2P2 Program

- During the 2000-2008 growth period, the **Coal Combustion Products Partnership** was a cooperative effort to encourage **beneficial use of coal ash** as an environmentally preferable alternative to disposal. Primary sponsors included:
  - U.S. Environmental Protection Agency (EPA)
  - American Coal Ash Association (ACAA)
  - Utility Solid Waste Activities Group (USWAG)
  - U.S. Department of Energy (DOE)
  - Federal Highway Administration (FHWA)
  - Electric Power Research Institute (EPRI)
  - U.S. Department of Agriculture Agricultural Research Service (USDA-ARS)
- EPA terminated C2P2 during its lengthy coal ash disposal rulemaking, Later, the EPA Inspector General conducted an investigation of the program and concluded that EPA should have done more to evaluate risks of beneficial uses before promoting them.
- EPA subsequently addressed the IG's criticism by developing a comprehensive "Risk Evaluation Methodology" and applying that methodology to the two largest beneficial uses – fly ash concrete and synthetic gypsum wallboard.

EPA Support for Beneficial Use

- EPA on February 7, 2014, released an exhaustive study re-affirming support for two major uses – fly ash in concrete and FGD gypsum in wallboard:
  - *"…environmental releases of constituents of potential concern (COPCs) from CCR fly ash concrete and FGD gypsum wallboard during use by the consumer are comparable to or lower than those from analogous non-CCR products, or are at or below relevant regulatory and health-based benchmarks for human and ecological receptors…* ***EPA supports the beneficial use of coal fly ash in concrete*** *and FGD gypsum in wallboard. The Agency believes that these beneficial uses provide significant opportunities to advance Sustainable Materials Management (SMM)."* http://1.usa.gov/1blyP62

2015 Production and Use Results

American Coal Ash Association Phone: 720-870-7897
38800 Country Club Drive Fax: 720-870-7889
Farmington Hills, MI 48331 Internet: www.ACAA-USA.org
Email: info@acaa-usa.org

2015 Coal Combustion Product (CCP) Production & Use Survey Report

Beneficial Utilization versus Production Totals (Short Tons)

2015 CCP Categories	Fly Ash	Bottom Ash	Boiler Slag	FGD Gypsum	FGD Material Wet Scrubbers	FGD Material Dry Scrubbers	FGD Other	FBC Ash	CCP Production / Utilization Totals
Total CCPs Produced by Category	**44,365,587**	**12,010,425**	**2,228,205**	**32,661,536**	**11,313,960**	**1,311,947**	**206,314**	**13,191,460**	**117,289,432**
Total CCPs Used by Category	**24,062,786**	**4,819,205**	**1,866,912**	**17,058,178**	**1,249,438**	**252,849**	**20,697**	**11,723,843**	**61,053,908**
1. Concrete/Concrete Products /Grout	15,737,238	570,092	33,290	409,134	0	0	0	0	16,749,754
2. Blended Cement/ Feed for Clinker	3,629,151	1,130,802	0	1,649,934	0	0	0	0	6,409,887
3. Flowable Fill	107,263	9,106	0	0	0	0	0	0	116,369
4. Structural Fills/Embankments	1,277,356	1,561,531	305,770	1,221,865	100,940	0	0	0	4,467,462
5. Road Base/Sub-base	178,281	311,779	21	0	0	0	0	0	490,081
6. Soil Modification/Stabilization	216,483	66,253	0	8,053	0	0	0	0	290,789
7. Mineral Filler in Asphalt	52,784	0	14,176	0	0	0	11,479	0	78,440
8. Snow and Ice Control	0	527,695	77,935	0	0	0	0	0	605,630
9. Blasting Grit/Roofing Granules	0	184,712	1,400,455	173	0	0	0	0	1,585,340
10. Mining Applications	1,128,682	73,416	0	807,280	0	215,974	0	11,593,760	13,819,113
11. Gypsum Panel Products (formerly Wallboard)	0	28,378	0	11,322,016	973,785	0	0	0	12,324,178
12. Waste Stabilization/Solidification	1,138,078	242	0	0	0	0	9,218	130,083	1,277,621
13. Agriculture	2,409	1,788	0	1,392,693	174,713	0	0	0	1,571,602
14. Aggregate	0	173,472	0	0	0	0	0	0	173,472
15. Oil/Gas Field Services	181,907	0	0	0	0	36,875	0	0	218,782
16. Miscellaneous/Other	413,152	179,940	35,265	247,030	0	0	0	0	875,387

Summary Utilization to Production Rate

CCP Categories	Fly Ash	Bottom Ash	Boiler Slag	FGD Gypsum	FGD Material Wet Scrubbers	FGD Material Dry Scrubbers	FGD Other	FBC Ash	CCP Utilization Total
Totals by CCP Type/Application	24,062,786	4,819,205	1,866,912	17,058,178	1,249,438	252,849	20,697	11,723,843	**61,053,908**
Category Use to Production Rate (%)	**54.24%**	**40.13%**	**83.79%**	**52.23%**	**11.04%**	**19.27%**	**10.03%**	**88.87%**	**52.05%**
2015 Cenospheres Sold (Pounds)	948,787	**Data in this survey represents 182 GWs of Name Plate rating of the total industry wide approximate 291 GW capacity based on EIA's July 2016 Electric Power Monthly.**							

8 Years – Overall Utilization

- 2008 - 44.53% - 60.6 million tons
- 2009 - 44.30% - 55.6 million tons
- 2010 - 41.20% - 52.4 million tons
- 2011 - 43.50% - 56.6 million tons
- 2012 - 47.28% - 51.9 million tons
- 2013 - 44.79% - 51.4 million tons
- 2014 - 48.00% - 62.4 million tons
- 2015 - 52.05% - 61.1 million tons

2012 -2015 utilization rates higher in part because of decreases in coal consumption attributed to natural gas competition and regulations closing older power plants.

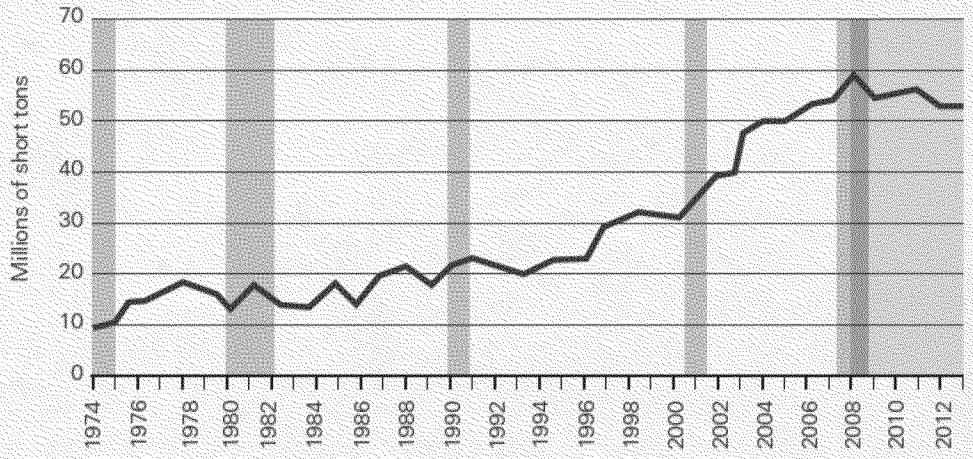
If 2009-2013 had simply remained equal with 2008's utilization, 26.4 million tons less coal ash would have been deposited in landfills and impoundments.

8 Years – Fly Ash in Concrete

- 2008 - 12.6 million tons
- 2009 - 9.8 million tons
- 2010 - 11.0 million tons
- 2011 - 11.8 million tons
- 2012 - 11.8 million tons
- 2013 - 12.3 million tons
- 2014 - 13.1 million tons
- 2015 - 15.7 million tons

Fly Ash Utilization vs. Economy

Utilization of CCPs has increased during recessions, but dropped during a period of regulatory uncertainty



U.S. Recessions
CCP Regulatory Uncertainty
Total CCP Utilization

Major U.S. Recessions

November 1973 to March 1975
January to July 1980
July 1981 to November 1982
July 1990 to March 1991
March to November 2001
December 2007 to June 2009

CCP Regulatory Uncertainty:

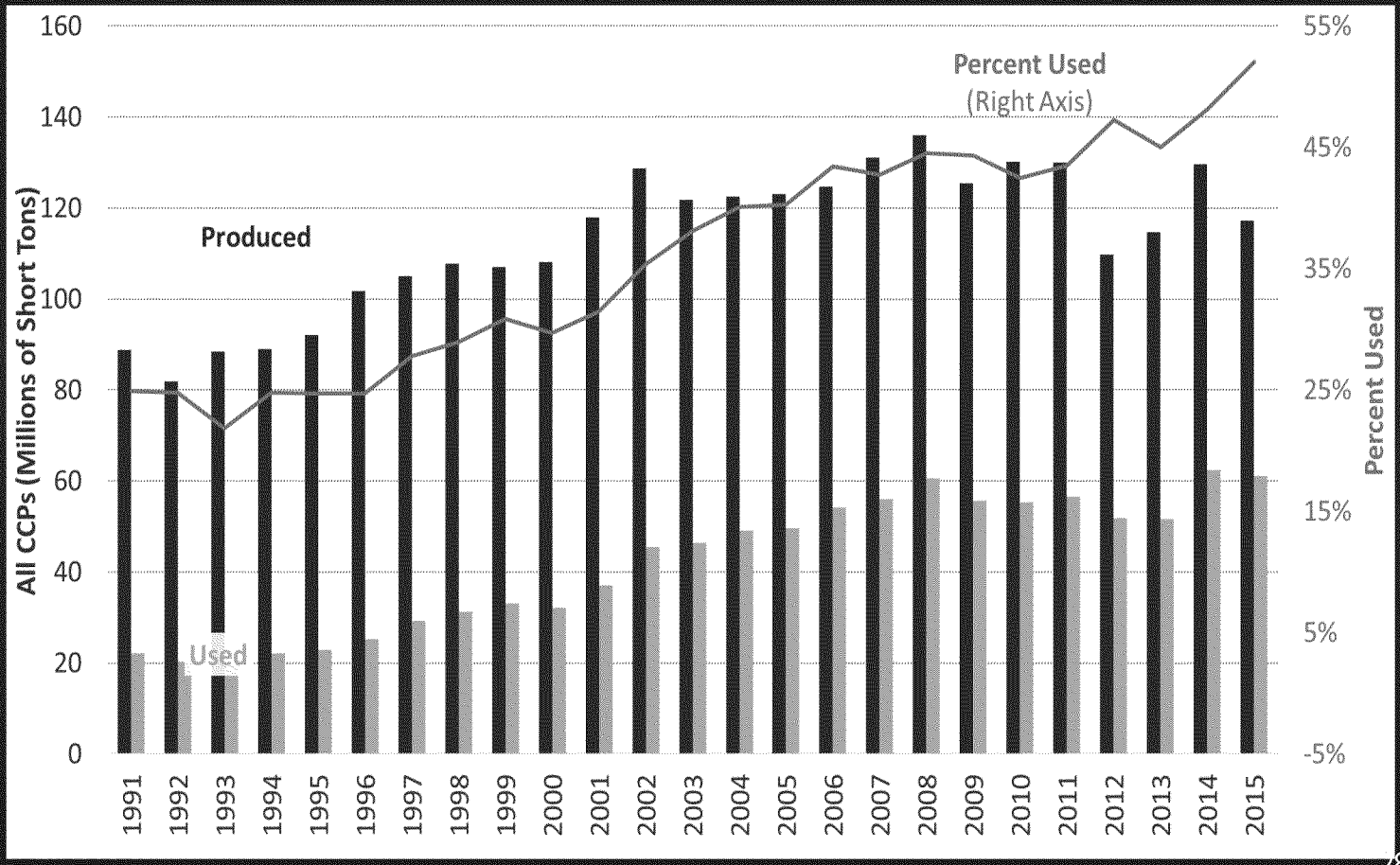
December 2008 to April 2015: EPA decision to reconsider the classification of CCPs as a hazardous waste

Figure 2. Regulatory uncertainty led to a decline in CCP markets

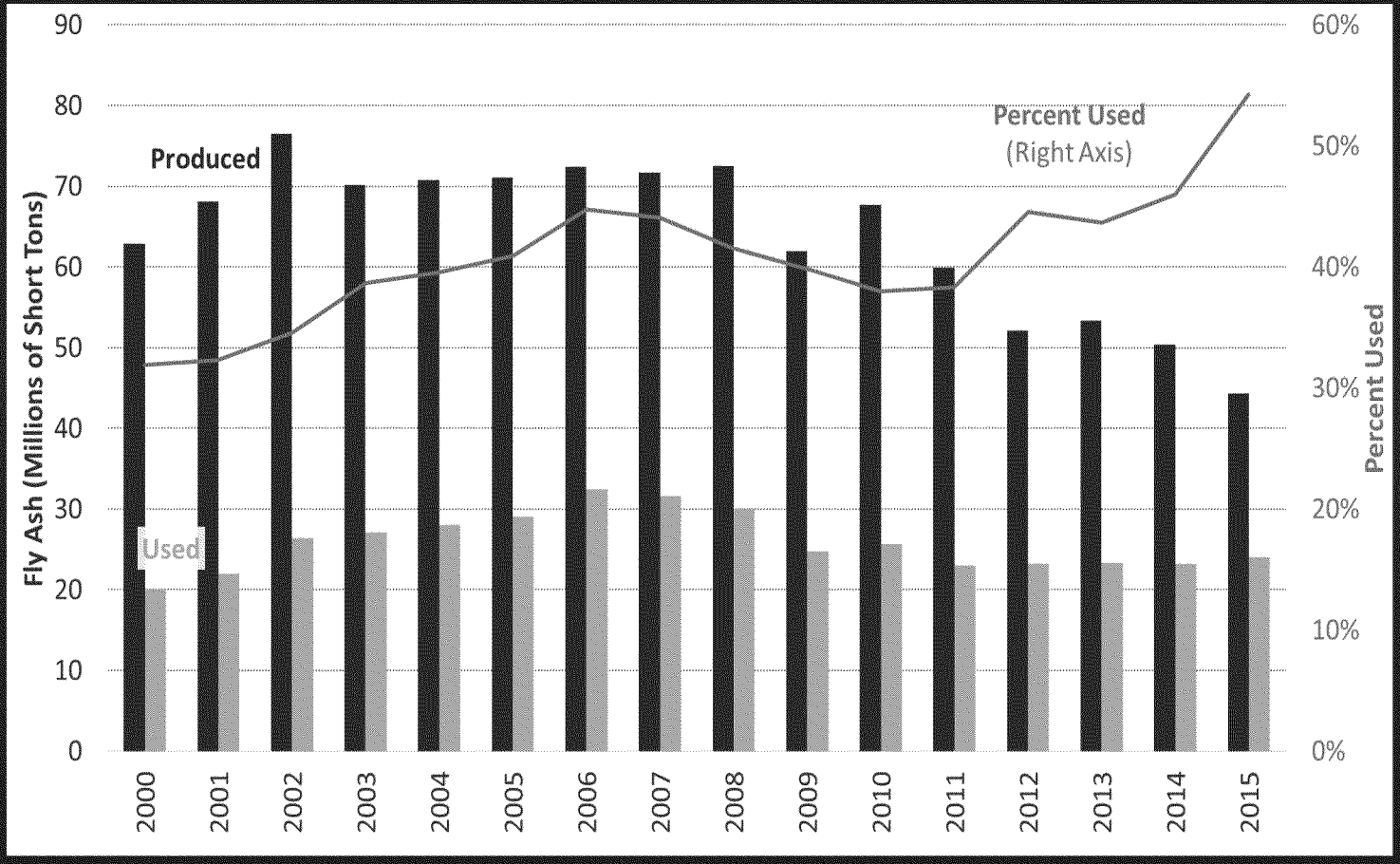
2015 Survey – Other Key Findings

- Use of coal fly ash in concrete increased 20 percent to 15.7 million tons – up from 13.1 million tons in 2014.
- Use of fly ash and bottom ash in structural fills declined 54 percent and 19 percent respectively. The decline of 1.9 million tons of utilization may be related to regulatory uncertainty.
- Utilization of a “non-ash” coal combustion product continued to increase. Synthetic gypsum use in panel products (i.e. wallboard) increased to 12.3 million tons in 2015. Use in agricultural applications – in which the gypsum improves soil conditions and prevents harmful runoff of fertilizers – increased to 1.6 million tons.
- Production of boiler slag declined 17 percent to 2.2 million tons as more power plants that produce this type of material were retired.
- Cenospheres saw utilization drop by 80 percent as impoundments began to close in response to EPA’s Final Rule for coal ash disposal.

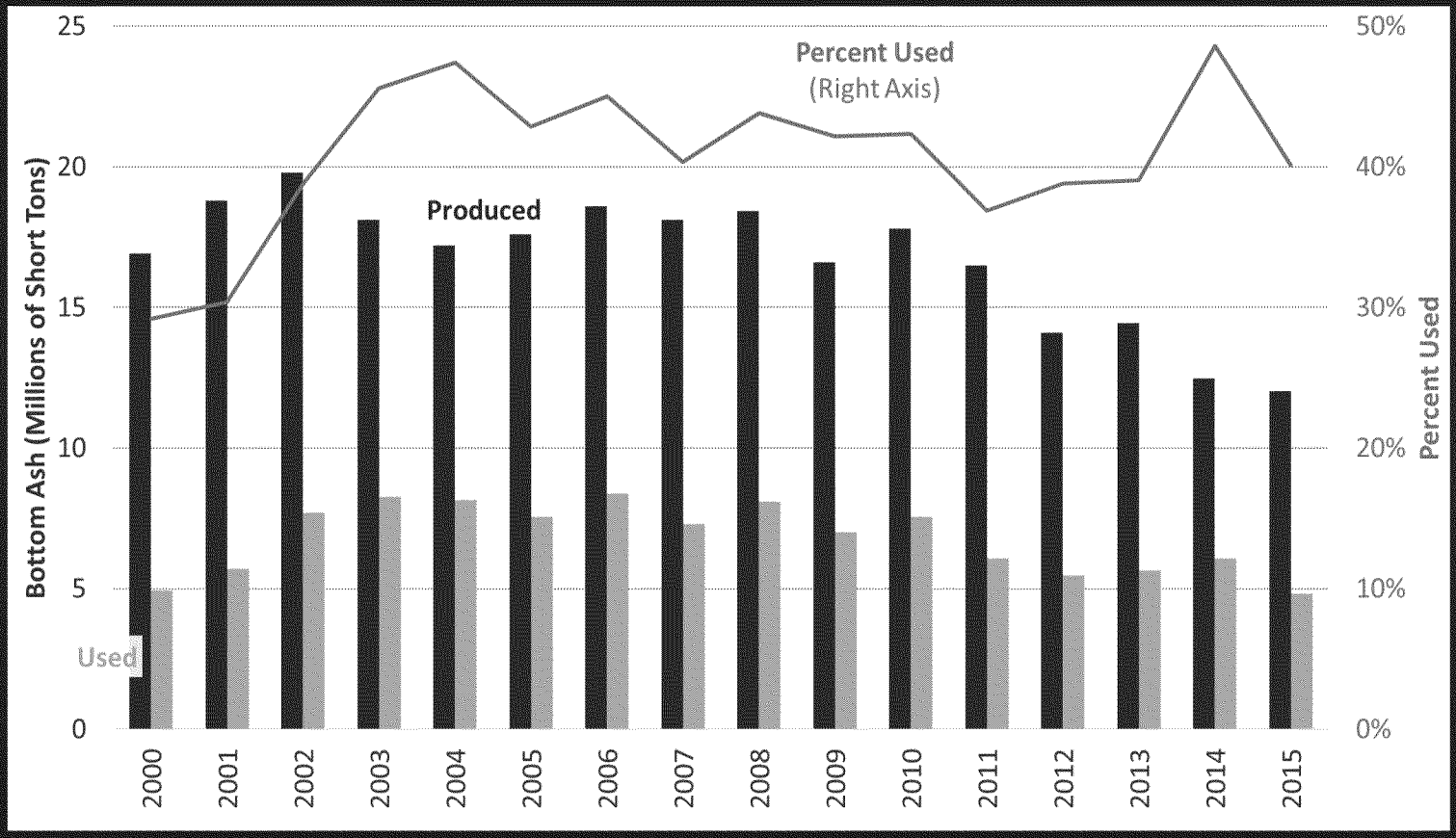
All CCPs Production and Use



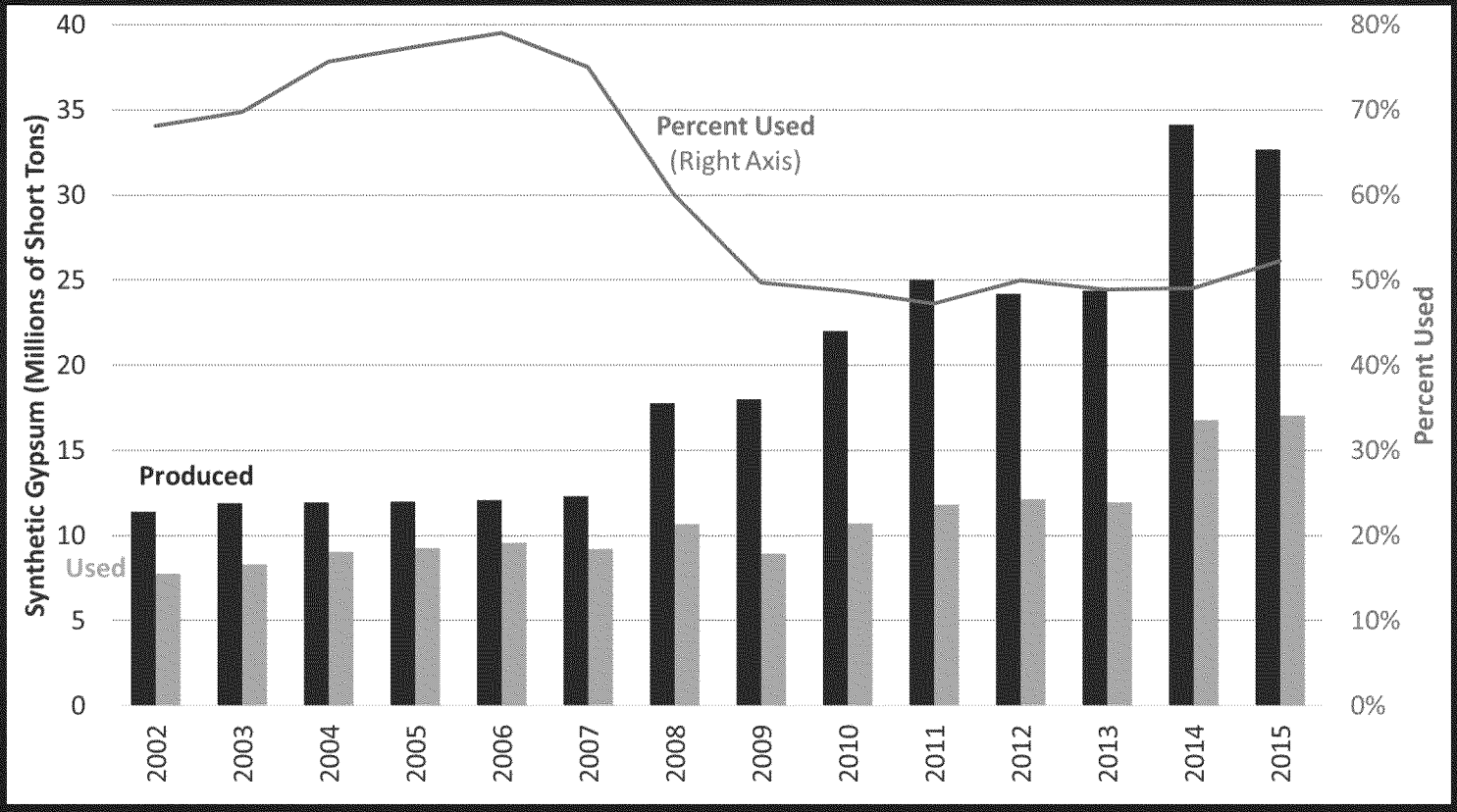
Fly Ash Production & Use



Bottom Ash Production & Use



Synthetic Gypsum Production & Use



Outlook for Future Supply

- Despite closure of coal-fueled power plants in response to environmental regulations and competition from other energy sources, coal is expected to remain a major source of U.S. electricity

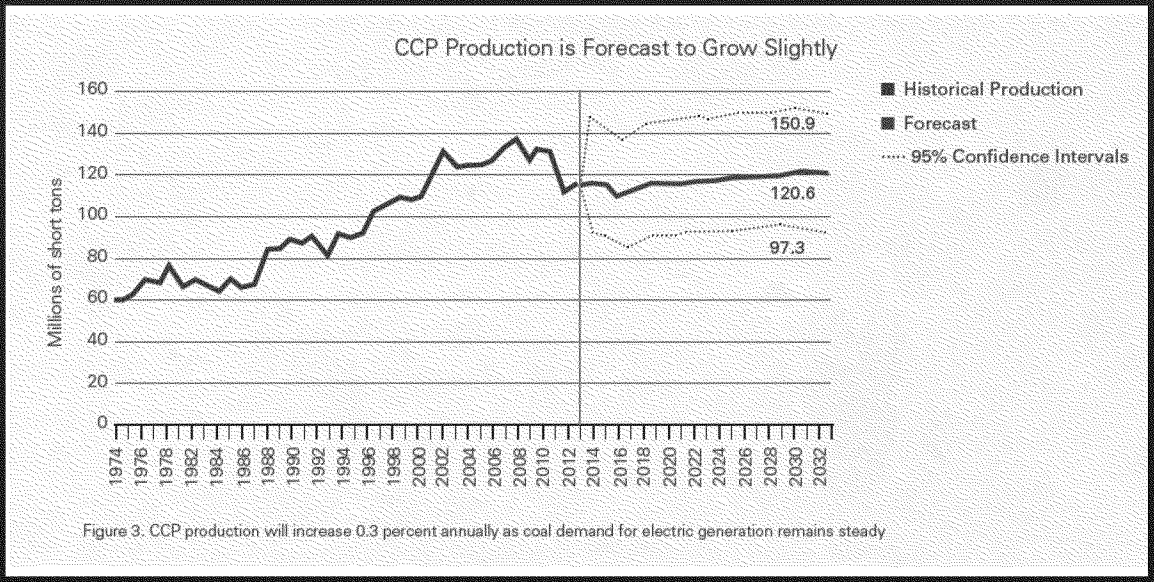


Figure 3. CCP production will increase 0.3 percent annually as coal demand for electric generation remains steady

Forecast for Future Use

- Power plants closing tend to be older, smaller generating units less likely to produce materials suitable for beneficial use without additional processing

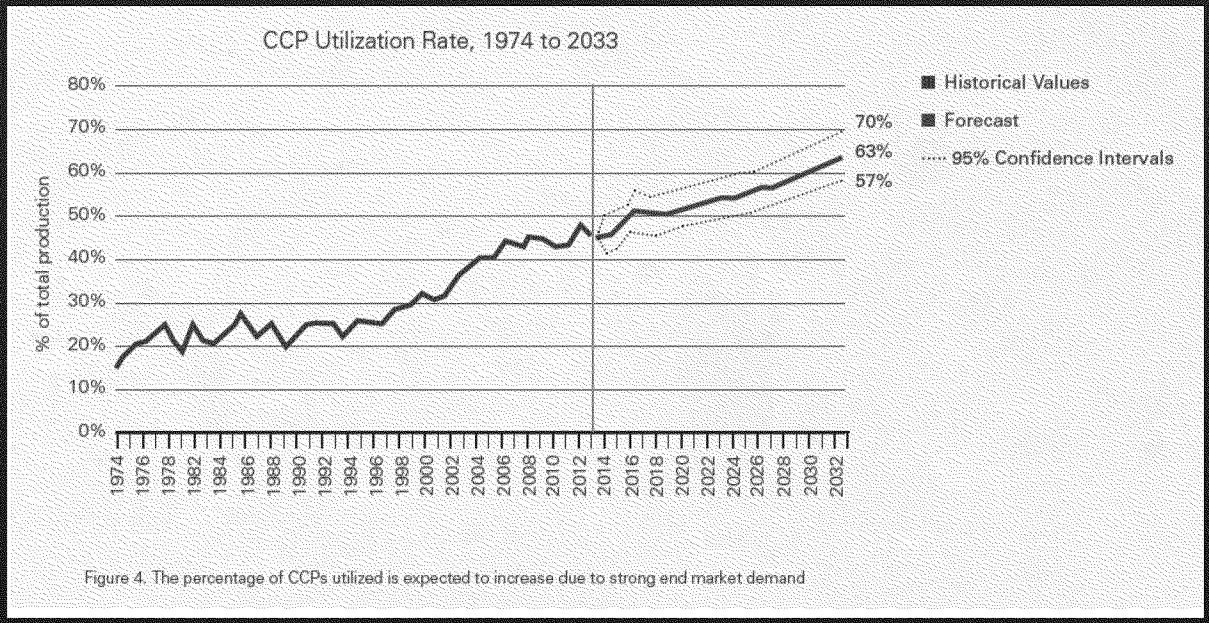
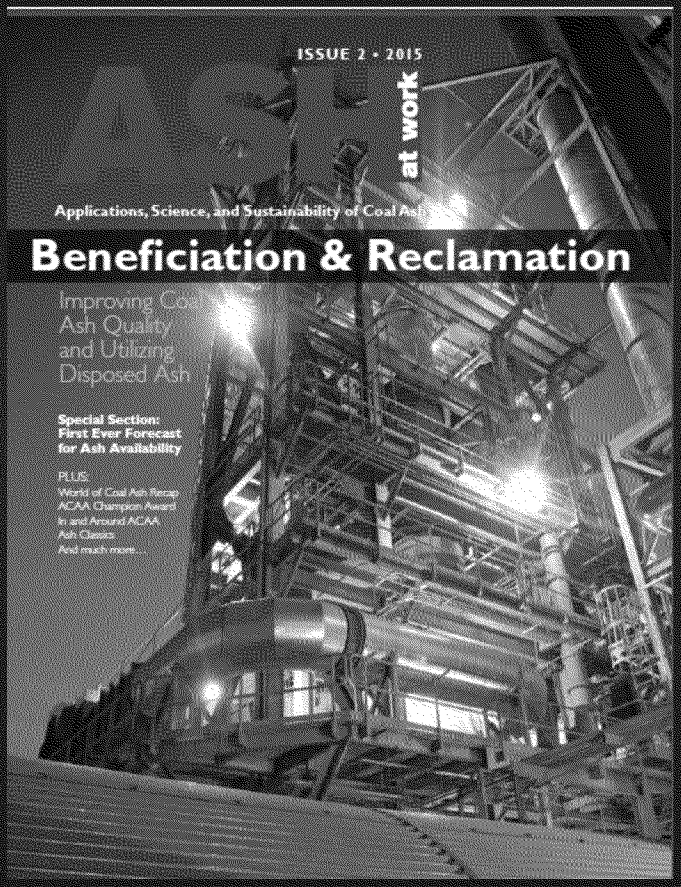


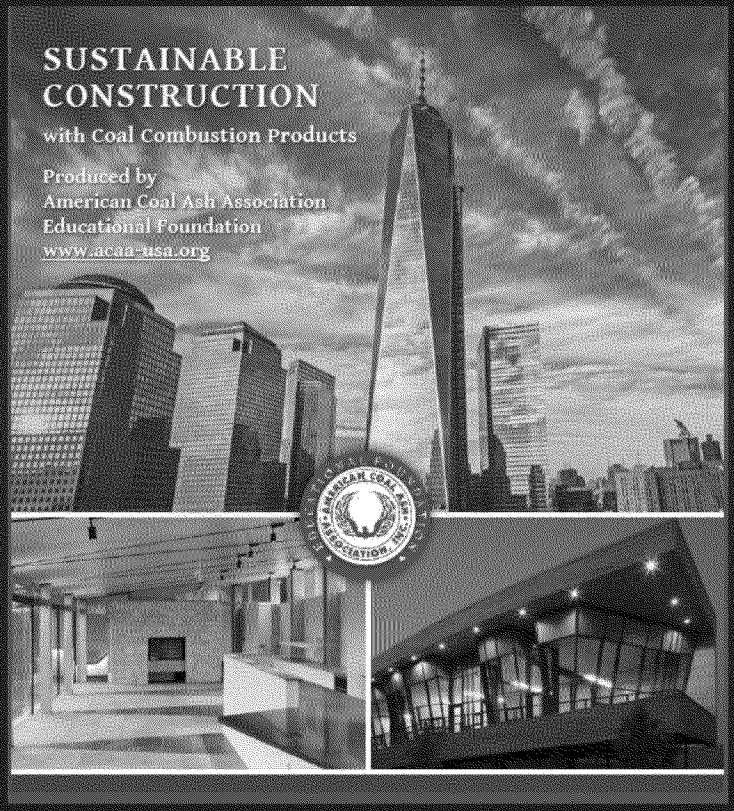
Figure 4. The percentage of CCPs utilized is expected to increase due to strong end market demand

Beneficiation and Reclamation



- Beneficial use industry today is actively developing strategies and technologies for utilizing previously disposed coal ash
- ACAA estimates more than 1.5 billion tons of coal ash since 1970

Built Environment Brochure



- https://www.acaa-usa.org/Portals/9/Files/PDFs/Sustainability_Construction_w_CCPs(Consolidated).pdf

Conclusions

- Coal ash beneficial use is worth protecting and expanding
  - Enormous environmental and economic benefits
- Coal ash beneficial use is safe
  - "Toxicity" similar to the materials coal ash replaces when recycled
- The protracted regulatory debate was really about enforcement authority
  - A "hazardous" designation won't get you better landfill designs
- Despite coal plant closures, there will continue to be a lot of coal ash to manage
  - **The best solution to coal ash disposal problems is to quit throwing coal ash away!**

Thank You!

AMERICAN COAL ASH ASSOCIATION

Thomas H. Adams, Executive Director

Personal Phone / Ex. 6 thadams@acaa-usa.org

John N. Ward, Government Relations Committee Chairman

Personal Phone / Ex. 6 wardo@wardo.com